EFFECTS OF AUGMENTED REALITY COLOURING APPLICATION TOWARDS CREATIVE THINKING AMONG PRESCHOOL CHILDREN THROUGH COMPUTERISED MEASUREMENT

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ABSTRACT

This study aimed to investigate the effects of augmented reality (AR) colouring application towards the preschool children's creative thinking. An instrument adapted from Torrance Test of Creative Thinking was developed and verified by five subject matter experts. An application titled FARCCS was created to computerise the measurement. Data collected through manual measurement were compared against the computerised measurement. The results showed statistical significant differences, indicating that the computerised measurement was more accurate and reliable, apart from being faster than human assessor. The effects of the AR colouring application were investigated through two quasi-experimental studies which were conducted in Kelantan, Malaysia. The first study was a single-group pre- and post-test quasi-experiment, conducted with 10 preschool children in School A, while the second study was a pre- and post-test control group quasi-experiment, carried out with 50 preschool children in School B. The data were analysed using nonparametric statistics, involving Mann-Whitney U test and Wilcoxon Signed Ranks test. The average scores of both studies improved significantly (School A: $Z = -2.565$, $p < 0.05$, Median = Very Good; School B: $U = 201.5$, $Z = -3.494$, $p < 0.05$, Median = Excellence). Results of the first study showed significant improvement in post-test fluency score ($Z = -2.0$, $p < 0.05$, Median = Fair), as compared to the pre-test fluency score. Meanwhile, results of the second study revealed significant improvement in originality scores ($U = 214.50$, $Z = -3.204$, $p < 0.05$, Median = Fair), as compared to the teaching and learning without AR. In conclusion, AR colouring application can be used to improve the fluency and originality aspects of creative thinking among preschool children. Implication of this research was, teaching and learning with AR for colouring activities in preschool settings can be practiced to develop creative thinking skills of the children.

KESAN PERISIAN MEWARNA REALITI TERIMBUH TERHADAP PEMIKIRAN KREATIF DALAM KALANGAN MURID PRASEKOLAH MELALUI PENGUKURAN BERKOMPUTER

ABSTRAK

Kajian ini bertujuan untuk mengkaji kesan perisian mewarna realiti terimbuh (AR) terhadap pemikiran kreatif dalam kalangan murid prasekolah. Satu instrumen yang diadaptasi dari *Torrance Test of Creative Thinking* telah dibangunkan dan disahkan oleh lima orang pakar pakar bidang khusus. Satu perisian bertajuk FARCCS telah dibangunkan bagi mengautomasikan pengukuran berkenaan. Data yang dikumpulkan melalui pengukuran manual dibandingkan dengan pengukuran berkomputer. Dapatan menunjukkan terdapat perbezaan statistik yang signifikan, menunjukkan pengukuran berkomputer lebih tepat dan konsisten, malah lebih cepat dari manusia sebagai pengukur. Kesan perisian mewarna dengan AR dikaji melalui dua kajian kuasi-eksperimen yang dijalankan di Kelantan, Malaysia. Kajian pertama ialah ujian pra- dan pasca kuasi-eksperimen bagi satu kumpulan yang melibatkan 10 kanak-kanak prasekolah di Sekolah A, manakala kajian kedua ialah ujian pra- dan pasca kuasi-eksperimen bagi kumpulan kawalan yang melibatkan 50 kanak-kanak prasekolah di Sekolah B. Data dianalisis dengan menggunakan ujian non-parameter, melibatkan ujian *Mann-Whitney U* and ujian *Wilcoxon Signed Ranks*. Skor purata dalam kedua-dua kajian menunjukkan peningkatan yang signifikan (Sekolah A: $Z = -2.565$, $p < 0.05$, Median = Sangat Baik; Sekolah B: $U = 201.5$, $Z = -3.494$, $p < 0.05$, Median = Cemerlang). Dapatan kajian pertama menunjukkan peningkatan yang signifikan dalam ujian-pasca bagi skor kelancaran ($Z = -2.0$, $p < 0.05$, Median = Sederhana), berbanding ujian-pra bagi skor kelancaran. Sementara itu, dapatan kajian kedua menunjukkan bahawa skor keaslian meningkat secara signifikan ($U = 214.50$, $Z = -3.204$, $p < 0.05$, Median = Sederhana), berbanding dengan pengajaran dan pembelajaran (PdP) tanpa AR. Kesimpulannya, perisian mewarna AR boleh digunakan bagi meningkatkan aspek kelancaran dan keaslian pemikiran kreatif dalam kalangan kanak-kanak prasekolah. Implikasi kajian ini ialah, PdP dengan AR bagi aktiviti mewarna dalam persekitaran prasekolah boleh diamalkan bagi membangunkan pemikiran kreatif kanak-kanak.

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LIST OF ABREVIATIONS

AR	Augmented Reality
DSKP	National Standard Curriculum for Preschool
EPRD	Education Planning and Research Department
FAR	Fast, Accurate and Reliable
HOTs	Higher Order Thinking Skills
ICT	Information and Communication Technology
JPN	State Education Department
KBSM	New Secondary School Curriculum
KBSR	New Primary School Curriculum
KSSR	Revised Primary School Standard-based Curriculum
MOE	Ministry of Education Malaysia
SPSS	Statistical Package for the Social Science
SME	Subject Matter Expert
TTCT	Torrance Tests of Creative Thinking
UPSI	Sultan Idris Education University, Malaysia
3D	Three Dimension

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S Normality Test Normality Test for The Single-Group Pre- and Post-Test Quasi-experiment

T Normality Test for The Pre- and Post-Test Control Group Quasi-experiment

U Pre-Test Data Collected in the Single-Group Pre- and Post-Test Quasi-experiment

V Statistical Comparison between Manual and Computerised Measurement

W Pre-Test Data Collected in The Pre- and Post-Test Control Group Quasi-experiment

X Certificate of Proofreading

Y Certificate of Intellectual Property Copyright

Z Certificate of Malaysia Technology Expo 2019 MTE Gold Award

CHAPTER 1

INTRODUCTION

1.1 Overview

This research aims to examine whether or not an augmented reality (AR) colouring activity that involves the use of a mobile app affects preschool children's creative thinking. In the course of achieving research objectives, the thesis offers preschool teachers a set of guiding principles for using AR technology in teaching and learning. According to Fisher and Frey (2015), it is difficult to know exactly what students are getting after the lesson, unless the teacher checks for understanding. Checking for understanding is a formative assessment and it plays a central role in outcome-based education (Baird, Andrich, Hopfenbeck, & Stobart, 2017), affording teachers to keep improving teaching and learning in future lessons in order to accomplish specific learning outcomes. Align with this proposition, the research was grounded on four teaching and learning steps proposed by Fisher and Frey (2015): 1) presenting

materials, lessons or learning opportunities; 2) checking for understanding; 3) providing student feedback and; 4) planning instruction based on students' misconception. These steps were followed when conducting two quasi-experiments in two national preschools located in Kelantan, Malaysia. The results of the study, as shown in Section 4.5 in Chapter 4, were meant for developing an instrument for measuring creative thinking among preschool children.

This thesis consists of six chapters. The first chapter discusses an overview of the research, including its background, problem statements, aims, research objectives, specific research questions and hypotheses. The second chapter provides the literature review of studies on the use of AR applications in colouring activities, particularly for improving and assessing creativity. The third chapter reports the methodology, research design and the development of a set of guiding principles. The fourth chapter depicts the design, development and validation of instruments to measure the level of creative thinking among preschool children. The fifth chapter juxtaposes the findings of both quasi-experiments and discusses how hypotheses formulated from research questions were tested to form research answers. The last chapter summarizes all conclusive propositions, while juxtaposing the overall contribution and limitations made throughout the research.

1.2 Background of the Research

The origin of this research came largely from the researcher's seven years of teaching experiences in two primary schools and eight years of experiences as a lecturer in two

matriculation colleges in Malaysia. Dealing with students of a wide range between five to 18 years old directly and indirectly offered this research an insight that individuals learn in different ways and develop their thinking skills in multiple ways (Gagné, 1972). The idea of pursuing a doctorate degree in Multimedia Education at the Faculty of Art, Computing and Creative Industry, Sultan Idris Education University, Malaysia (UPSI) with this research topic was inspired by the increasing use of ICT among school teachers to facilitate teaching and learning process. In a nutshell, this research attempted to put an idea of ICT application into practice, and then examined its effectiveness toward creative thinking through a quasi-experimental study on preschool children in Malaysia. The fundamental assumption made in this research was that using AR app in teaching and learning activities can increase the level of creative thinking among preschool children.

This research used a form of multimedia application called AR to help the teaching and learning process focus on colouring activities (Billinghurst, Clark, & Lee, 2015; Santos et al., 2016). AR was selected because it was seen as a multimedia application that can combine elements such as image, audio and animation, affording AR to receive positive feedback among educators and children (Di Serio, Ibáñez, & Kloos, 2013; Westerfield, Mitrovic, & Billinghurst, 2015). Moreover, AR can show virtual three dimensional (3D) objects superimposed over the real world (Billinghurst et al., 2015; Santos et al., 2016). For instance, an AR colouring app called Quiver allows users to point their mobile device to a colouring worksheet in order to visualize an animated 3D figure with their choice of colours (Billinghurst et al., 2015). In particular, the animation element in AR made significant contribution in various subject matters

of education for the past decades (Kogilathah, Ahmad Zamzuri M.A, & Tan, 2014). The animation also can yield positive effects on the creative thinking ability of targeted learners (Billinghurst et al., 2015; Diegmann, Schmidt-Kraepelin, Eynden, & Basten, 2015; Kerawalla, Luckin, Seljeflot, & Woolard, 2006; Santos et al., 2016).

Two studies were found directly related to colouring and creative thinking. In a joint-research between Disney Research and two universities, (Zünd et al., 2015) attempted to use AR colouring book to engage children for boosting imagination and creativity. Zünd et al. (2015) coined the idea of "augmented creativity" and claimed that their app can enhance real-world interaction, discovery, exploration, and imagination. In a study conducted by Feng, Yang and Xiao (2017), an AR app called MagicToon was used to facilitate drawing and colouring. Feng et al. (2017) revealed that MagicToon can better stimulate children's creativity compared to other similar apps.

Human being with higher order thinking skills (HOTs) are able to apply knowledge, skills and values in making reasoning and reflection to solve problem, make decision innovatively and creatively (Bahagian Pembangunan Kurikulum, 2014a). According to Bahagian Pembangunan Kurikulum (2014a), HOTs refers to a collection of four skills, i.e. applying, analyzing, evaluating and creating, in order to cultivate critical thinking and creative thinking among pupils or students (Bahagian Pembangunan Kurikulum, 2014b). Critical thinking and creative thinking were introduced in the Malaysia National Curriculum in 1994 through New Primary School Curriculum or *Kurikulum Bersepadu Sekolah Rendah* (KBSR) and New Secondary School Curriculum or *Kurikulum Bersepadu Sekolah Menengah* (KBSM) (Bahagian

Pembangunan Kurikulum, 2014c). The Ministry of Education Malaysia (MOE) re-emphasised critical thinking and creative thinking through a revised Primary School Standard-based Curriculum or *Kurikulum Standard Sekolah Rendah* (KSSR) in 2011 (Bahagian Pembangunan Kurikulum, 2014c) due to the lack of intensive implementation (Pusat Perkembangan Kurikulum, 2002). Then HOTs were re-introduced in KSSR again in 2013 (Ministry of Education Malaysia, 2013). All the HOTs elements in revised version of Bloom's taxonomy, as shown in Figure 1.1 was embedded into the learning standard of preschool curriculum, and the embed of HOTs elements was sustained until post-secondary level (Ministry of Education Malaysia, 2013).

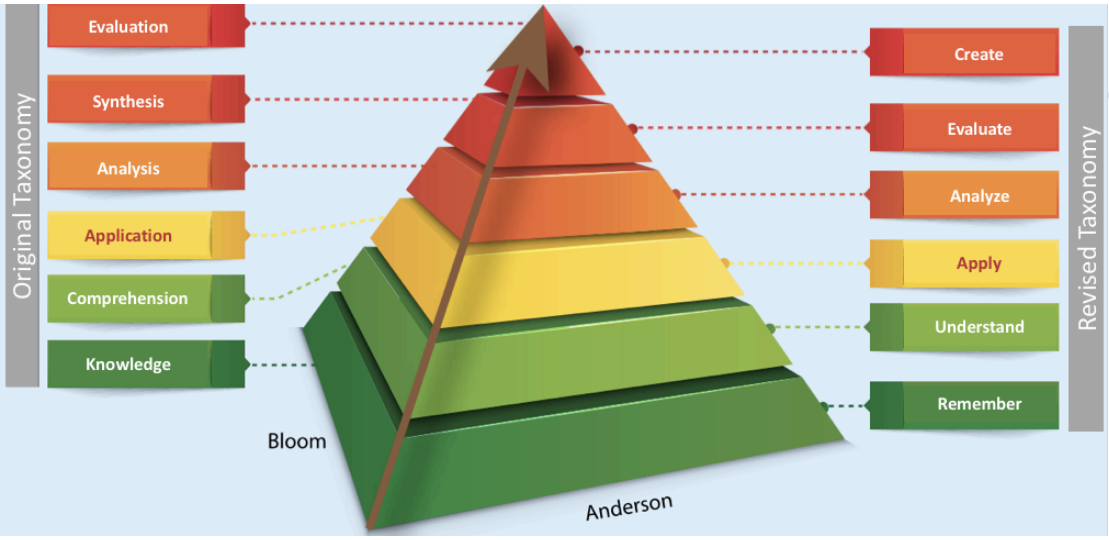

Figure 1.1. HOTS Elements (Adapted from Bahagian Pembangunan Kurikulum, 2014a, p. 3)

Revised version of Bloom's taxonomy for teaching, learning and assessment demonstrated that these are six classifications of cognitive processes when learners work with knowledge, they are: 1) remember; 2) understand; 3) apply; 4) analyse; 5) evaluate; and 6) create. In the first taxonomy, learners can recall facts and basic

concepts by defining and remembering them. The second taxonomy is understand which means learners are capable to explain ideas and concepts by classifying and describing them. In the third taxonomy, learners use information in new situations by applying, implementing, demonstrating and interpreting them. In the fourth taxonomy, learners can analyse by draw connections among ideas, differentiating and examining them. In the fifth taxonomy, which is learners can evaluate which is capable to justify the stands or decisions by arguing and critiquing them. The last element in the taxonomy is create, which is learners can produce new or novel work by designing and developing them (Anderson, Krathwohl, & Bloom, 2001). The revised version of Bloom's taxonomy shows that learning is far beyond than remembering and understanding the concepts. Learners can be the innovator of generating new concepts and ideas. In this sense, the learning contents of particular subject matters and the associated teaching and learning approaches deployed by teachers in the classroom should match the cognition level of pupils or students, allowing the students to remember, understand, apply, analyse, evaluate and create.

When teachers construct questions to elicit learning performance, the elements of HOTs ought to be taken into consideration. However, only a small number of students can answer questions creatively, i.e. thinking out of the box, offering imaginative yet wrong answers that go beyond normality (Eastaway, 2013). According to Eastaway (2013), human beings tend to find logically right answer from the children instead of embracing creatively wrong answers. In this sense, children's creativity was killed by responses like "No, that would never work". Therefore, creative thinking must be taught in the early childhood to cultivate HOTs because it is feasible to teach children

to think creatively at this stage and this can be done in a variety of ways (Torrance, 1972a).

One suitable way to teach creative thinking in nowadays scenario is using multimedia in education. The use of multimedia in education may lead to innovative teaching and learning processes. As highlighted in the Education Development Master Plan 2013-2025 (Ministry of Education Malaysia, 2013), teachers were also encouraged to use information communication technology (ICT), especially when preparing and providing multimedia module for use inside and outside the classroom in order to enhance the quality of teaching and learning (Ministry of Education Malaysia, 2017).

Creativity was defined by Torrance (1977) as the contribution of original ideas using a different point of view, or a new way of looking at problems. Torrance (1977) insisted that creativity can also be defined as a successful step in the production of something new or original product, the results of the process embodied in an invention, a scientific theory, an improved product, a literary work, a musical composition, a new design, recombining ideas or the like. Meanwhile, creative thinking is a necessity of learning environment in the 21st Century (Partnership for 21st Century Learning, 2015). Human creativity has become a defining feature of economic life, in which the creativity must be nurtured and nourished since childhood (Peck, 2005; Torrance, 1972a). After conducting the teaching and learning session in subject matters like art, music, and physical education, the success or failure of the teaching and learning would be depending on children's capability to think creatively during the intervention (Torrance, 1972a). The capability can be measured using four criteria: fluency, flexibility, originality and elaboration (Torrance, 1972a). Even though creativity could

be something that people easily identify without referring to any guiding definition, the level of creativity among children can still be differentiated as either more creative or less creative, when specific criteria are referred in the judgment (Amabile, 1983). According to Amabile (1983), there must be a distinction between creative performance and ordinary performance. The results are likely to influence the generation and development of creative individuals (Amabile, Conti, Coon, Lazenby, & Herron, 1996), as a resource for communities (Peck, 2005). This research adopted the measurement of creative thinking through the criteria introduced by Torrance (1972a) to determine the effects of AR colouring app upon preschool children's creative thinking.

MOE consistent with the effort of re-engineering Malaysian education with ICT. Integrating technology like AR in teaching and learning has been set as one of the initiatives taken by the government in building a solid foundation for revamping Malaysia education system (Ministry of Education Malaysia, 2013). According to the Education Development Master Plan, all the teaching and learning activities conducted in preschool settings must follow the preschool syllabus with the aid of ICT. However, the results of a study conducted by Sandra, Abu Bakar and Norlidah (2013) in Malaysia, showed that teachers in the national preschools were positive in their attitudes toward employing ICT, although these teachers were still lacking of actual practices.

1.3 Problem Statement

In the formation of the problem statement of this study, four main issues were identified: 1) the lack of research in creative thinking in relation to colouring; 2) the

limited resources in art and play materials; 3) the lack of studies demonstrated how to measure the creative thinking of application or software in the market; and 4) the lack of standard assessment tools for measuring creative thinking specifically in colouring activity (see Figure 1.2). These issues directed the phenomenon of regarding colouring activity as a filler of teaching and learning, without taking the opportunity to improve children's creative thinking in preschool education.

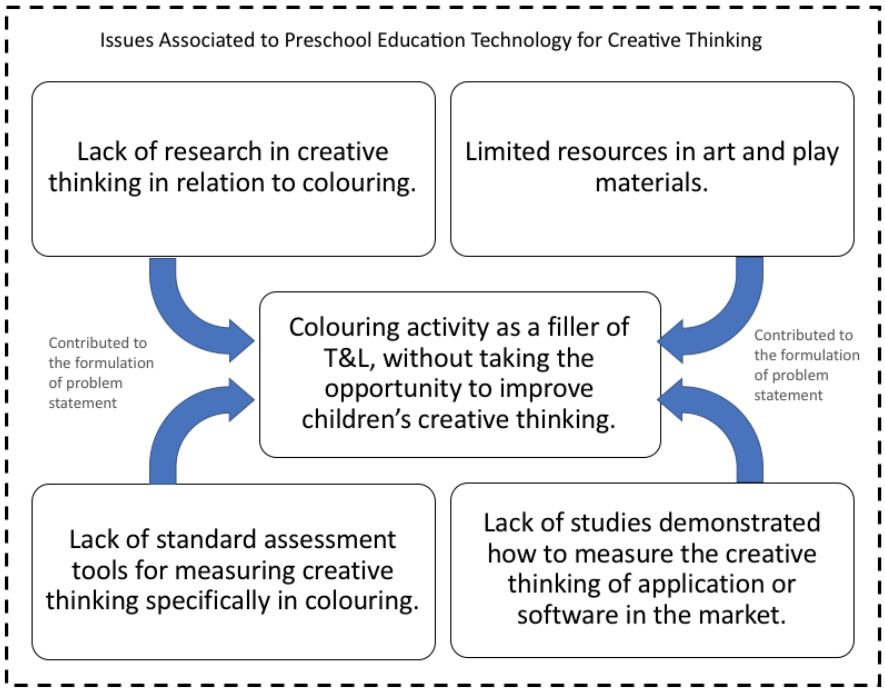

Figure 1.2. Issues and Problem Statement

The first issue was the lack of empirical research studies in creative thinking in the relation to AR and colouring activities (refer to Section 2.3.2 in Chapter 2 for further discussion). Twelve electronic databases were searched to examine the presence of academic publications associated to colouring and creative thinking among preschool children, especially in education field, information technology and social science (refer to Table 2.1 in Chapter 2).

The second issue was the lack of resources in art and play materials. These resources, e.g. clay, sand pit, educational toys, etc, are normally supplied upon the establishment of a preschool. However, once the preschool runs out of those materials, the school administrators are not able to restock, forcing teachers to conduct classes without art and play materials, hence the ease of chalk-and-talk teaching approach. In addition, preschool teachers are lacking of references to design creative activities in the classroom for the children (Azli Ariffin & Roselan Baki, 2014). In such conditions, the use of ICT in the classroom was found motivating, adding enjoyment in children learning (Sheridan & Samuelsson, 2003), despite certain usage of ICT in preschool failed to show explicit positive effect on children's academic performance (Sharifah Nor Puteh & Kamarul Azman Abd Salam, 2011). To augment the benefit of ICT in preschool settings, teachers have to be creative when applying specific ICT in classroom settings (Sandra Rahman et al., 2013; Sharifah Nor Puteh & Kamarul Azman Abd Salam, 2011). Therefore, this research intended to fill in this gap by developing a set of guiding principles and teacher-led instruction for implementing ICT, specifically AR app in teaching and learning process.

The third issue was the lack of research-based measuring instruments for creative thinking among preschool children (refer to Section 2.4 in Chapter 2 for further discussion). As a result, it was difficult, if not impossible to reveal the effects of AR apps in the consumer market. The use of AR app such as MagicBook, CCDU AR, CityViewAR, Living Sasquatch and the like was found having the potential to change how human interact with digital contents positively (Billinghurst et al., 2015). From early studies conducted in the 1960's until the widespread availability around the 2010's, there had been steady progress towards the goal of combining real and virtual

worlds seamlessly (Billinghurst et al., 2015). Nevertheless, there was still a lack of academic literature presenting and justifying sufficiently the educational potential and affordances of AR technology in primary education (Fotaris, Pellas, Kazanidis, & Smith, 2017). Hence empirical research was necessary to examine different facets of AR applications for preschool and primary education. All above-mentioned studies which were related to AR app should base on sound theoretical frameworks or reliable evaluation methods to further establish the pedagogy of AR-based applications in different subject maters. Studies associated to five types of mobile app on the market place claimed that the use of mobile apps can enhance creative thinking, specifically story-making app (Kucirkova, Messer, Sheehy, & Fernández Panadero, 2014), AR colouring app (Magnenat et al., 2015), painting and colouring app (Tokuhisa, Kamiyama, & Tokiwa, 2015), puppetry app (Wohlwend, 2015), drawing app (Yadav & Chakraborty, 2017). Nonetheless, none of these studies demonstrated how to measure creative thinking among children to prove the effects of those apps.

The last issue was related to the third, as there was a lack of standard assessment tools for measuring creative thinking, specifically in colouring activities for preschool children (refer to Section 2.4 in Chapter 2 for further discussion). When comparing to most creative thinking assessment instruments, Torrance Tests of Creative Thinking (TTCT) was found to be the most widely used instrument (Bahar & Ozturk, 2018; Rababah, 2018; Said-Metwaly, Fernández-Castilla, Kyndt, & Van den Noortgate, 2018). However, previous research shown that different activity would contribute to the development of creative thinking on different constructs of TTCT (refer to Section 2.4 in Chapter 2). Thus, this research was conducted to examine the effects of AR colouring activity towards four constructs of creative thinking among preschool children.

All of the four issues mentioned above contributed to the formulation of problem statement in this research. Due to the lack of empirical research studies, resources, measurement methods and assessment tools for creative thinking in AR colouring activities among preschool children, colouring activities were conducted as fillers of teaching and learning, rather than being the opportunity to improve children's creative thinking (refer to Section 2.2.2 in Chapter 2). With reference to the issues elaborated above, this research was conducted to examine the effects of AR colouring activity towards creative thinking among preschool children. An off-the-shelf AR app was used in a colouring activity, while a rubric with a bespoke software was developed specifically for the colouring activity to measure the level of creative thinking. The AR colouring mobile app allows users interact actively with virtual and physical objects while engaging in colouring activities.

1.4 Research Aim and Objectives

This research aimed to determine the effects of AR colouring activity towards creative thinking among preschool children. A provisional guiding principle was developed with reference to the conceptual framework (refer to Section 1.6) and the theoretical framework of this research (refer to Section 1.7). An instrument was prepared for measuring the level of creative thinking in order to carry out two quasi-experiment studies with preschool children. Five research objectives were set to achieve the research aim:

1. To compare the level of creative thinking before and after using AR colouring mobile app.
2. To compare the use of multiple colours among preschool children before and after using AR colouring mobile app.
3. To compare the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app.
4. To compare the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app.
5. To compare the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app.

1.5 Research Questions and Hypotheses

Five research questions were built based on the research objectives. These objectives were operationalised into the following research questions:

1. Is there a significant difference of preschool children's creative thinking before and after using AR colouring mobile app?
2. Is there a significant difference in the use of multiple colours among preschool children before and after using AR colouring mobile app?
3. Is there a significant difference in the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app?
4. Is there a significant difference in the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app?

5. Is there a significant difference in the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app?

Five null hypotheses and five alternative hypotheses were formulated for conducting the first quasi-experiment, in which statistical tests were run in search for research answers, as Table 1.1.

Table 1.1

Hypotheses of the Single-Group Pre- and Post-test Quasi-experiment

	Objective	Question	Hypothesis
1.	To compare the level of creative thinking before and after using AR colouring mobile app.	Is there a significant difference of preschool children's creative thinking before and after playing AR colouring mobile app?	1. H_0: There was no significant difference between the overall pre-test and post-test total scores. 2. H_1: There was a significant difference between the overall pre-test and post-test total scores.
2.	To compare the use of multiple colours among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the use of multiple colours among preschool children before and after using AR colouring mobile app?	3. H_0: There was no significant difference between the overall pre-test and post-test fluency scores. 4. H_1: There was a significant difference between the overall pre-test and post-test fluency scores.
3.	To compare the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app?	5. H_0: There was no significant difference between the overall pre-test and post-test flexibility scores. 6. H_1: There was a significant difference between the overall pre-test and post-test flexibility scores.
4.	To compare the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app?	7. H_0: There was no significant difference between the overall pre-test and post-test originality scores. 8. H_1: There was a significant difference between the overall pre-test and post-test originality scores.
5.	To compare the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app?	9. H_0: There was no significant difference between the overall pre-test and post-test elaboration scores. 10. H_1: There was a significant difference between the overall pre-test and post-test elaboration scores.

The second quasi-experiment, 50 null hypotheses and 50 alternative hypotheses were formulated for statistical testing in search for answers, as Table 1.2.

Table 1.2

Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

Objective	Question	Hypothesis
1. To compare the level of creative thinking before and after using AR colouring mobile app.	Is there a significant difference of preschool children's creative thinking before and after playing AR colouring mobile app?	1. H_0: There was no significant difference between the overall pre-test ranks of the control group and the experimental group. 2. H_1: There was a significant difference between the overall pre-test ranks of the control group and the experimental group.
		3. H_0: There was no significant difference between the overall post-test ranks of the control group and the experimental group. 4. H_1: There was a significant difference between the overall post-test ranks of the control group and the experimental group.
		5. H_0: There was no significant difference between the overall pre-test and post-test. 6. H_1: There was a significant difference between the overall pre-test and post-test.
		7. H_0: There was no significant difference between the overall pre-test and post-test in the control group. 8. H_1: There was a significant difference between the overall pre-test and post-test in the control group.
		9. H_0: There was no significant difference between the overall pre-test and post-test in the experimental group. 10. H_1: There was a significant difference between the overall pre-test and post-test in the experimental group

(continued)

Table 1.2 (continued)

Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

	Objective	Question	Hypothesis
2.	To compare the use of multiple colours among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the use of multiple colours among preschool children before and after using AR colouring mobile app?	11. H_0: There was no significant difference in pre-test fluency scores between the control group and the experimental group. 12. H_1: There was a significant difference in pre-test fluency scores between the control group and the experimental group.
			13. H_0: There was no significant difference in overall post-test fluency scores between the control group and the experimental group. 14. H_1: There was a significant difference in overall post-test fluency scores between the control group and the experimental group.
			15. H_0: There was no significant difference between the overall pre-test and post-test fluency scores. 16. H_1: There was a significant difference between the overall pre-test and post-test fluency scores.
			17. H_0: There was no significant difference between the overall pre-test and post-test fluency scores in control group. 18. H_1: There was a significant difference between the overall pre-test and post-test fluency scores in control group.
			19. H_0: There was no significant difference between the overall pre-test and post-test fluency scores in the experimental group. 20. H_1: There was a significant difference between the overall pre-test and post-test fluency scores in the experimental group.

(continued)

Table 1.2 (continued)

Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

Objective	Question	Hypothesis
3. To compare the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the use of multiple colouring techniques among preschool children before and after using AR colouring mobile app?	21. H_0: There was no significant difference in pre-test flexibility scores between the control group and the experimental group. 22. H_1: There was a significant difference in pre-test flexibility scores between the control group and the experimental group.
		23. H_0: There was no significant difference in overall post-test flexibility scores between the control group and the experimental group. 24. H_1: There was a significant difference in overall post-test fluency scores between the control group and the experimental group.
		25. H_0: There was no significant difference between the overall pre-test and post-test flexibility scores. 26. H_1: There was a significant difference between the overall pre-test and post-test flexibility scores.
		27. H_0: There was no significant difference between the overall pre-test and post-test flexibility scores in the control group. 28. H_1: There was a significant difference between the overall pre-test and post-test flexibility scores in the control group.
		29. H_0: There was no significant difference between the overall pre-test and post-test flexibility scores in the experimental group. 30. H_1: There was a significant difference between the overall pre-test and post-test flexibility scores in the experimental group.

(continued)

Table 1.2 (continued)

Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

Objective	Question	Hypothesis
4. To compare the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the attempt of adding new object in colouring activity among preschool children before and after using AR colouring mobile app?	31. H_0: There was no significant difference in pre-test originality scores between the control group and the experimental group. 32. H_1: There was a significant difference in pre-test originality scores between the control group and the experimental group.
		33. H_0: There was no significant difference in overall post-test originality scores between the control group and the experimental group. 34. H_1: There was a significant difference in overall post-test originality scores between the control group and the experimental group.
		35. H_0: There was no significant difference between the overall pre-test and post-test originality scores. 36. H_1: There was a significant difference between the overall pre-test and post-test originality scores.
		37. H_0: There was no significant difference between the overall pre-test and post-test originality scores in the control group. 38. H_1: There was a significant difference between the overall pre-test and post-test originality scores in the control group.
		39. H_0: There was no significant difference between the overall pre-test and post-test originality scores in the experimental group. 40. H_1: There was a significant difference between the overall pre-test and post-test originality scores in the experimental group.

(continued)

Table 1.2 (continued)

Hypotheses of the Pre- and Post-test Control Group Quasi-experiment

Objective	Question	Hypothesis
5. To compare the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app.	Is there a significant difference in the choice of colour weight in colouring activity among preschool children before and after using AR colouring mobile app?	41. H_0: There was no significant difference in pre-test elaboration scores between the control group and the experimental group. 42. H_1: There was a significant difference in pre-test elaboration scores between the control group and the experimental group.
		43. H_0: There was no significant difference in overall post-test elaboration scores between the control group and the experimental group. 44. H_1: There was a significant difference in overall post-test elaboration scores between the control group and the experimental group.
		45. H_0: There was no significant difference between the overall pre-test and post-test elaboration scores. 46. H_1: There was a significant difference between the overall pre-test and post-test elaboration scores.
		47. H_0: There was no significant difference between the overall pre-test and post-test elaboration scores in the control group. 48. H_1: There was a significant difference between the overall pre-test and post-test elaboration scores in the control group.
		49. H_0: There was no significant difference between the overall pre-test and post-test elaboration scores in the experimental group. 50. H_1: There was a significant difference between the overall pre-test and post-test elaboration scores in the experimental group.

1.6 Conceptual Framework

According to the Oxford Dictionaries Online (2018), a "framework" can be defined as a basic structure underlying a system, concept, or text. Frameworks can come in several names such as conceptual framework, practical framework and theoretical framework with difference shapes, sizes and perspectives (Bordage, 2009). Different frameworks were used by the researcher to facilitate this research, including the presentation of concepts, methods and findings. In general, a conceptual framework provides an idea of how well the variables are connected together according to the research needs (Ivey, 2015). In this research, a conceptual framework was developed through a three-step approach: a) list down all the key concepts related to the research; b) make a relationship among all the concepts through a relationship diagram; and c) synthesize the relationship diagram to produce and fine tune a conceptual framework.

In the first step, all the key concepts related to the research were identified and listed down in each sticky note (see Figure 1.3). The words included augmented reality, teaching aid, guiding principle, preschool children, preschool teacher, Malaysia school, theories, creativity, creative thinking, technology, example, colouring, TTCT, fluency, flexibility, originality, elaboration, app, gender, age, measurement, manual and computerize.

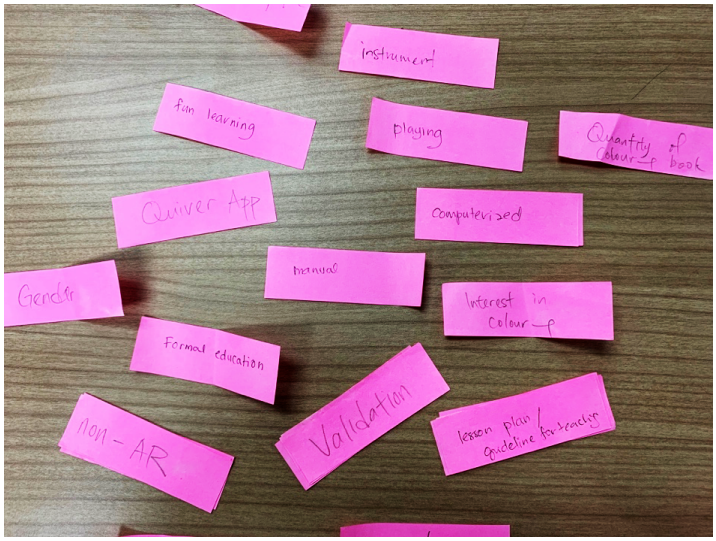

Figure 1.3. Key Concepts Related to the Research

After that, every relationship between two concepts was defined using a verb to make it logical, rational and meaningful. The second step involved producing drafts of the framework based on the preliminary structure, in the course of creating a proper diagram of the conceptual framework. Figure 1.4 is a draft of the conceptual framework that depicted all the key concepts and relationships between those concepts. In final step, the draft of conceptual framework was compacted and extracted to form a synthesized and finalized framework. Figure 1.5 showed the final version of conceptual framework, built for this research in order to visualize how the four constructs may be potentially interrelated.

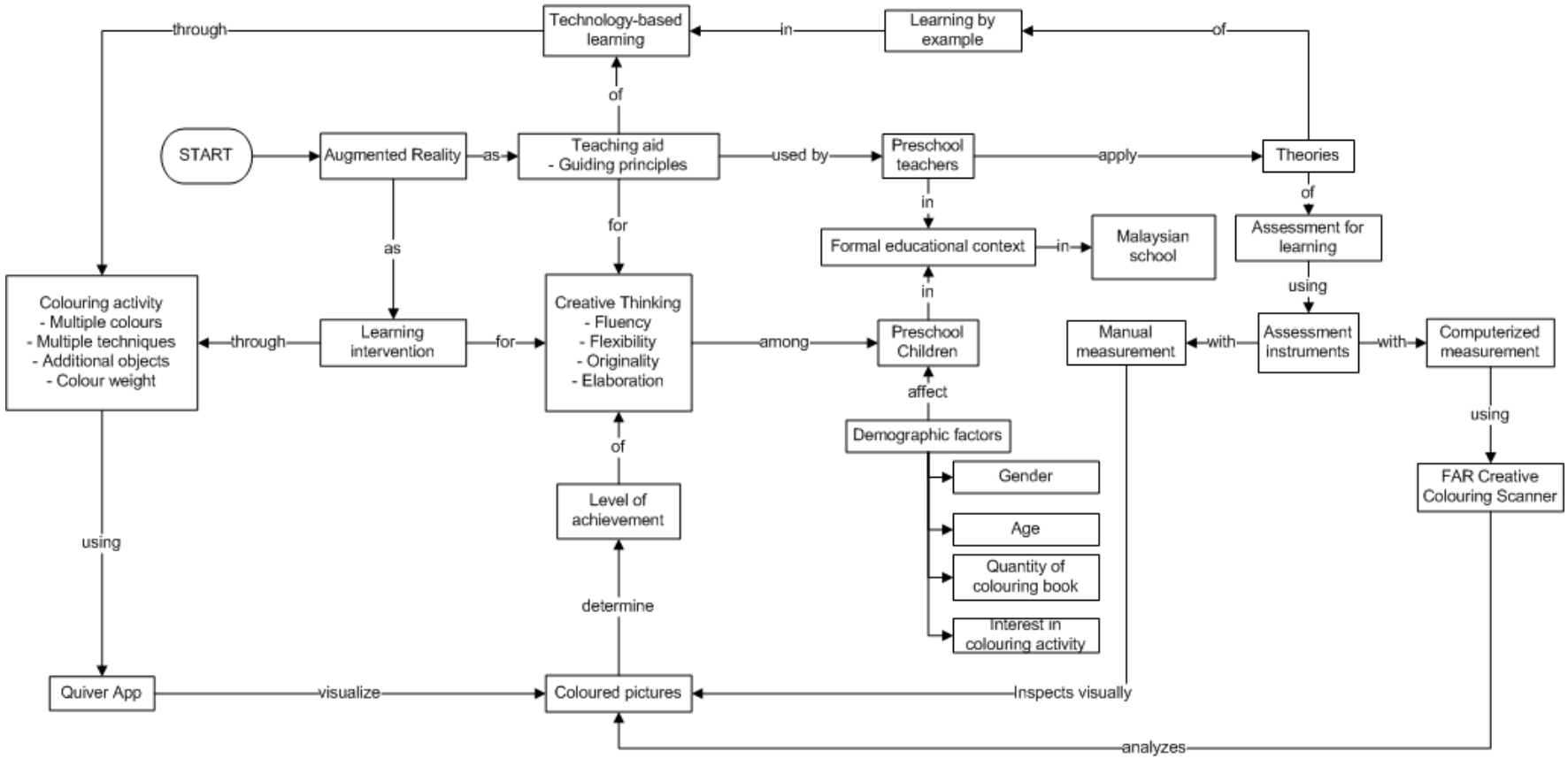

Figure 1.4. Key Concepts and its Relationship

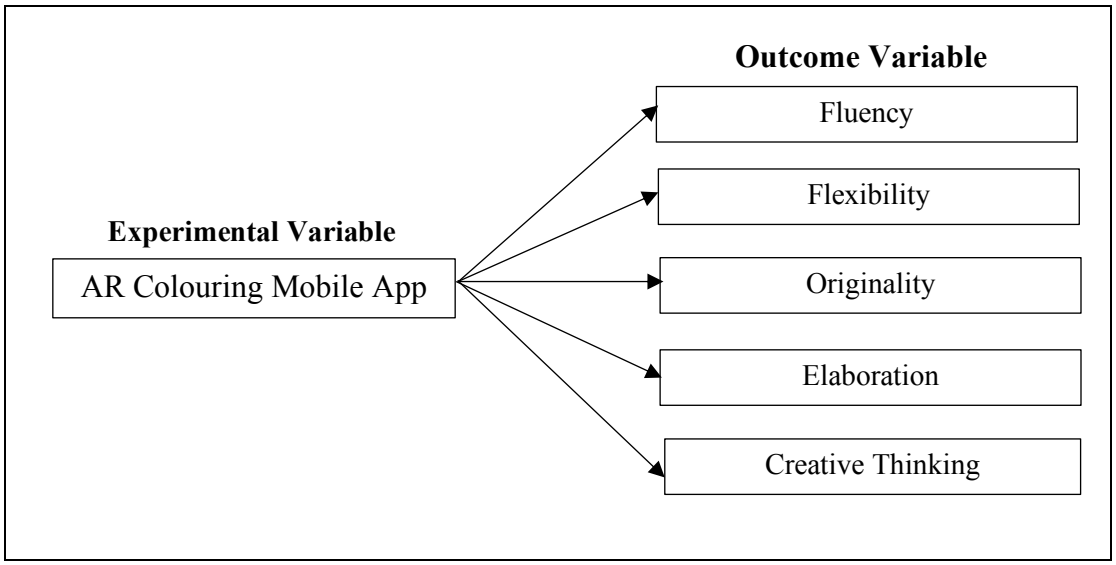

Figure 1.5. The Final Conceptual Framework

As shown in Figure 1.5, AR colouring mobile app was the independent variable or experimental variable, tested to examine the effects of AR colouring mobile app towards creative thinking, specifically in fluency, flexibility, originality and elaboration. In this sense, creative thinking, fluency, flexibility, originality and elaboration were the dependent variables or outcome variables in the study. The framework was developed according to pairwise comparisons that involve the relationships between AR colouring mobile app with creative thinking.

1.7 Theoretical Framework

A theoretical framework refers to the theory used to guide the research (Imenda, 2014). As the evaluation of AR is essential towards achieving high level of creative

thinking in school, Gagne's nine events of instruction and TTCT was chosen to offer an explanation and guidance toward answer the research problem (see Figure 1.6).

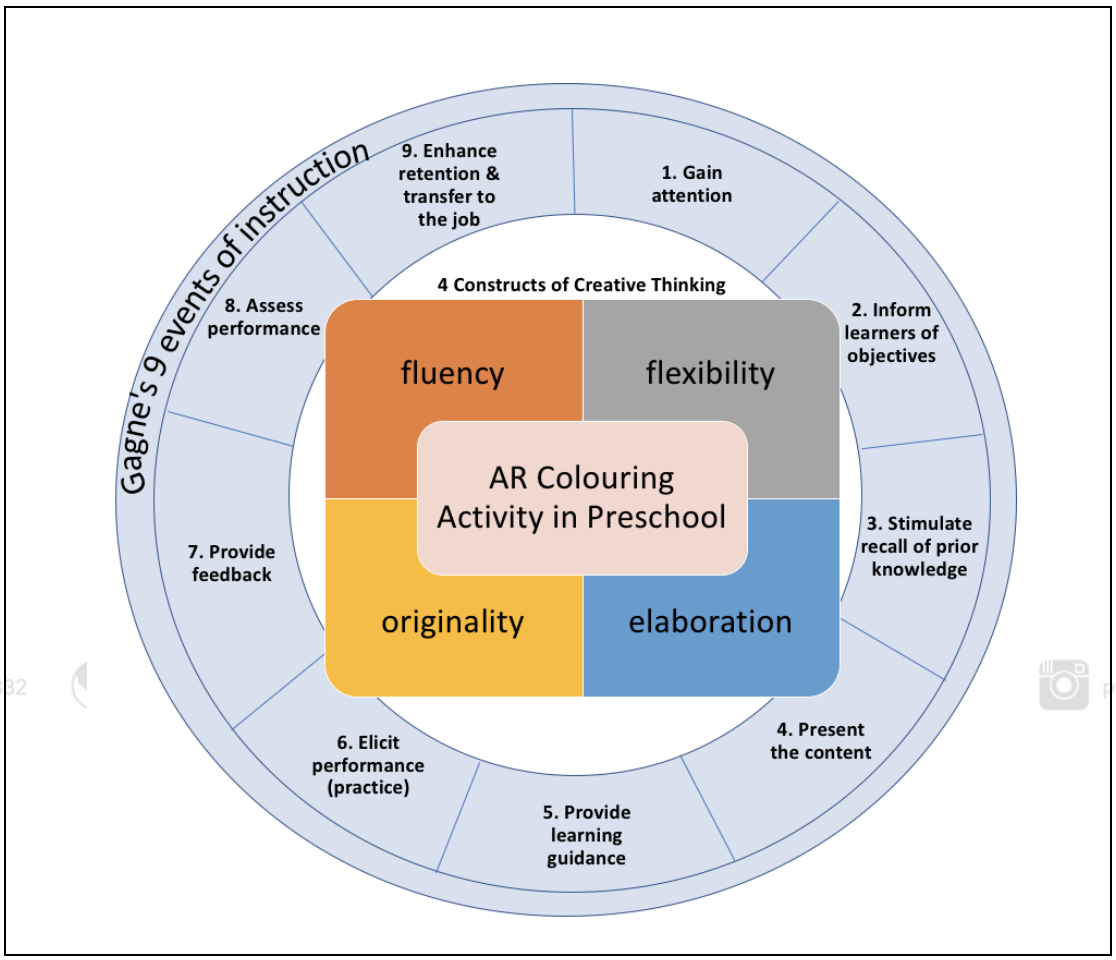

Figure 1.6. Theoretical Framework

Grounded on cognitivism theory of learning, Gagne's nine events of instruction was an instructional strategy that permits one to predict the effects of specific instructional conditions on a learner's cognitive processing and the resulting learned capabilities (Smith & Ragan, 1996). Gagné (1985) described the nature of an instructional strategy as an attempt to relate in terms of internal and external conditions. Internal conditions included motivational states and previous knowledge

that was stored in long-term memory accessible for new learning, conversely an external conditions, refers to the set of events collectively called instruction.

Gagne's nine events of instruction, conceived as a set of stimuli which give support to internal learning processes. The model helps trainers, educators and instructional designer to design their teaching and learning sessions properly. It also provide guidance for an effective and systematic learning process. These nine events begin with: 1) gain attention; 2) inform learners of objective; 3) stimulate recall of prior knowledge; 4) present the content; 5) provide learning guidance; 6) elicit performance or practise; 7) provide feedback; 8) assess performance; and 9) enhance retention and transfer.

The nine events of instruction can be divided into three segments: 1) preparation; 2) instruction and practice; and 3) assessment and transfer. In the first segment (preparation) consist of three events: 1) gain attention; 2) inform learners of objective; 3) stimulate recall of prior knowledge. The second segment (instruction and practice) included: 4) present the content; 5) provide learning guidance; 6) elicit performance or practise; and 7) provide feedback. The last segment (assessment and transfer) consist of two last events: 8) assess performance; and 9) enhance retention and transfer. In outlining this research's theoretical model, all the nine event were used even it was not necessarily to include all events on all occasions (Smith & Ragan, 1996).

The development of the theoretical model was aided with four TTCT original constructs (Torrance, 1972b): 1) fluency; 2) flexibility; 3) originality; and 4) flexibility. The constructs were adapted for measuring creative thinking through colouring activity

as 1) multiple colours; 2) multiple colouring techniques; 3) additional novel object; and 4) colour weight. Discussion on the TTCT instrumentation was discussed further in Chapter 4.

1.8 Research Scope

This research is conducted under the social science academic settings (see Figure 1.7). It focused on creative thinking skill among preschool children because during this age, their creative and colour exploring are being built in this age (Aminah Ayob, Nani Menon, Rohani Abdullah, & Jameyah Sheriff, 2013). Child creative thinking and aesthetic development milestones are attached in Appendix A for reference. As depicted by Pathways (2019), during the age four until six years old children are able to colour and begin to imitate shapes. Moreover, according to the Centers for Disease Control and Prevention (2015), preschool children should be able to identified colours, showing affection and show rapid development of mental skills. Child development milestones and four to six years abilities are attached in Appendix B and Appendix C for reference.

Even though the HOTs have two types of thinking, critical thinking was not included in the research because the ability to make critical judgement was more suitable for children six years old and above. In terms of limitation, this research was constrained by three matters, namely the participants, the device used to conduct the study and app including colouring worksheet.

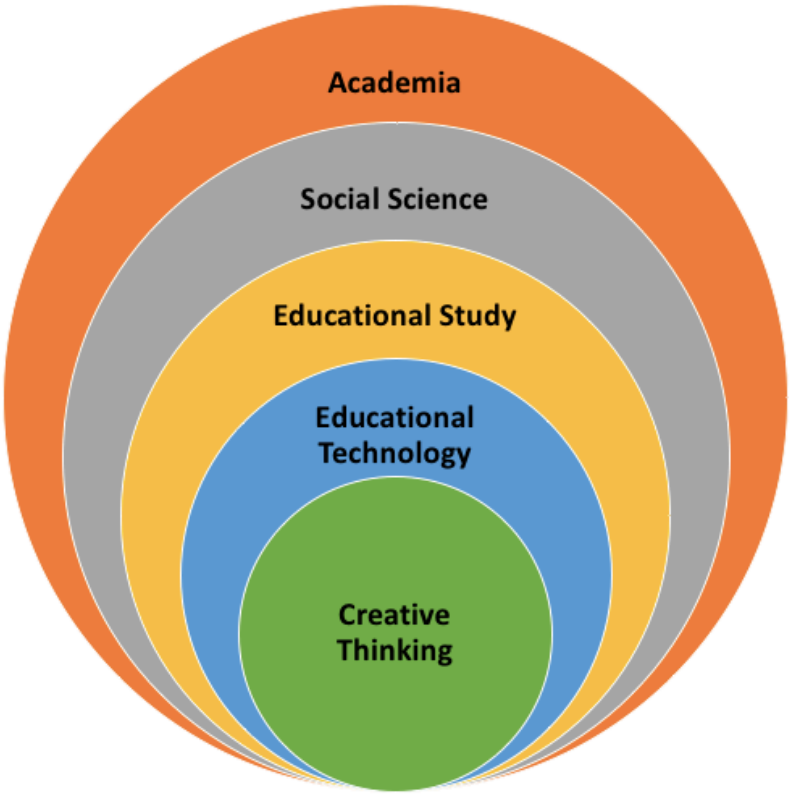

Figure 1.7. Scope and Position of Creative Thinking Studies in Academia

1.8.1 The Participants

This research was limited to Malaysian preschool children aged five and six years old, as opposed to all age groups in preschool childhood in Malaysia. As depicted by the *Program Permata Negara* module (Aminah Ayob et al., 2013), children older than four years old generally have sufficient cognitive capacity to express their creativity through colouring.

The participants of this research were recruited from two national preschools at the Kelantan area. The first school, School A is among several school in Malaysia,

where the environment, facilities and facilitation was represent all the national preschool in Malaysia (refer to Section 3.8.1 in Chapter 3). The second school, School B was chosen as the second case for this research because of its unique roles and functions in Malaysia for the existence of a Samsung SMART Classroom (refer to Section 3.8.2 in Chapter 3). Two different setup of preschools have been chosen to conduct this research aiming to get a relatively unified finding and conclusion.

1.8.2 The Device Used

The mobile devices used in first quasi-experimental study were five to ten inch tablet computers. However, for the second quasi-experimental study, only ten inch tablet computers used, instead of using smartphones with smaller screen size. The identical tablets would be used to collect data with the participants to get more consistent result.

1.8.3 The App and Colouring Worksheet

The AR colouring mobile app used with permission in this research was called Quiver app (refer to Appendix D). It was install in android OS and used two colouring worksheets: 1) pukeko bird; and 2) dot day, was explain further details in Section 3.7.1 in Chapter 3. The size of the worksheet was A5 size. Student was asked to colour the objects only (regardless the background). This two justification were tested suitable to be complete within one hour teaching and learning session and were explained further in Chapter 3.

1.9 Significance of this Research

The first part of the research would offer a set of guiding principles can be referred by preschool teachers for teaching and learning assist by AR technology. The use of AR is an attempt to leverage ICT support and increase the level of creative thinking in education field. It is keen to explore the potential of mobile learning integration by utilizing the power of teaching and learning of the mobile devices. The significant pedagogical change is very important. Students in the 21st century need teachers who can apply digital technologies collaboratively to design effective and innovative learning environment (Partnership for 21st Century Learning, 2015).

The second part of the research would offer an AR assessment instrument for measuring the creative thinking among preschool children. The assessment is part of the assessment for learning or formative assessment. It will be able teacher to provide future lesson to improve teaching and learning thereby improve the children performance.

The doctoral research was conducted to support education transformation that takes place over 13 years. Malaysian education mission is to pursue excellence with increased creative and critical thinking and improve performance on Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) in top third of the systems (Ministry of Education Malaysia, 2013).

1.10 Operational Definition

There were five variables with phrases used along this research. The term was synthesized from the nominal meanings into one definition which is contextualize for this research title and context.

1.10.1 Creative Thinking

For this research, creative thinking is related to or involved the use of the original ideas, opinions and imagination to create coloured picture using colour pencil based on four TTCT construct (Torrance, 1972b); 1) fluency; 2) flexibility; 3) originality; and 4) flexibility.

1.10.2 Fluency

This research measures the level of creative thinking in which fluency construct shows the ability of using multiple colours.

1.10.3 Flexibility

Flexibility construct shows the ability of using multiple colouring techniques to create different texture in colouring.

1.10.4 Originality

Originality construct refers to the ability of adding new object inside of the original uncoloured image.

1.10.5 Elaboration

Elaboration construct refers to the ability to complete the colouring task without left any space uncoloured.

1.11 Summary

This research was conducted to determine the effect of AR app towards creative thinking among preschool children specific in colouring activity. This chapter outlined the inspiration and motivation which lie behind the conduct of this research, the problem statements which lead to the research aims and research questions, the hypothetical propositions and presenting the research framework diagram. This chapter also clarified the significant, scope and limitation of the research and a few operational definitions that used in this research. Discussion on literature review regarding creative thinking, preschool, involvement of ICT and AR in education and discussion on the previous researches were further examined in next chapter, Chapter 2.